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**B7C**
**Selected US specifications from IPC sub-classes**
**B29H B60C**

## (54) Retreading tyres

(57) A heat curable tread stock (11) is placed onto a prepared carcass (10). An induction heating element (15) is placed within the crown area (C) of the tyre, and a further induction heating element (30) is placed externally around the crown area of the tyre. The crown area of the tyre is compressed against the carcass by a taper ring 43 whilst a periodic electro-magnetic current is induced in the two elements 15, 30 by a transformer primary coil 53. The transformer core 51 has an upper portion 52 which is pivoted into position by a hydraulic actuator 54.

Fig.5.

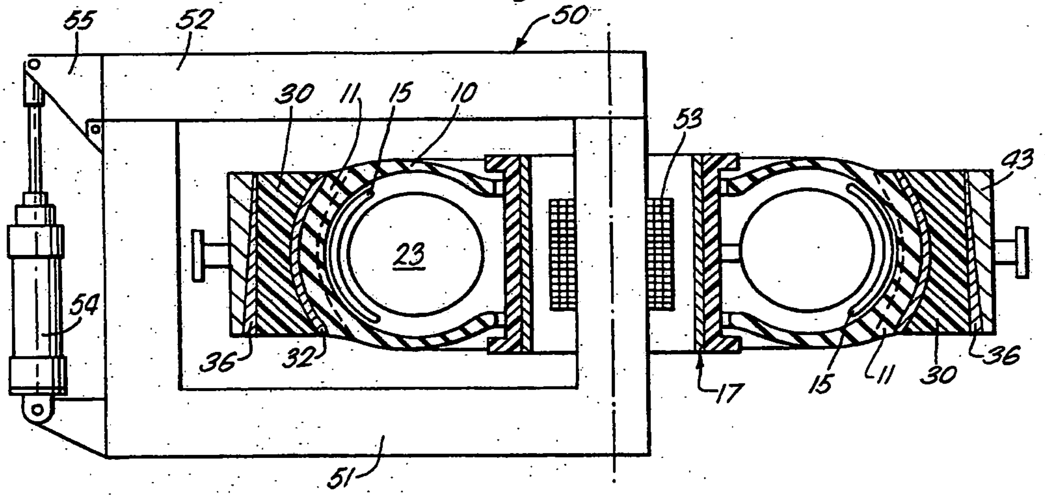

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Fig.1.

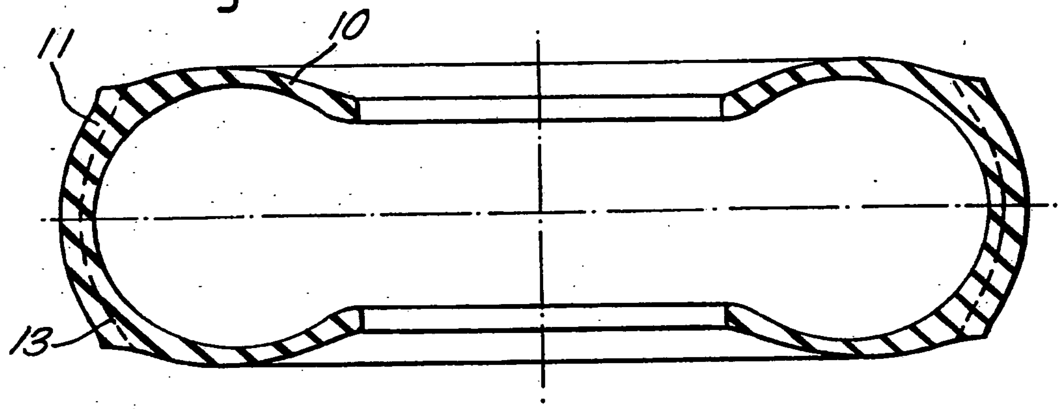


Fig.2.

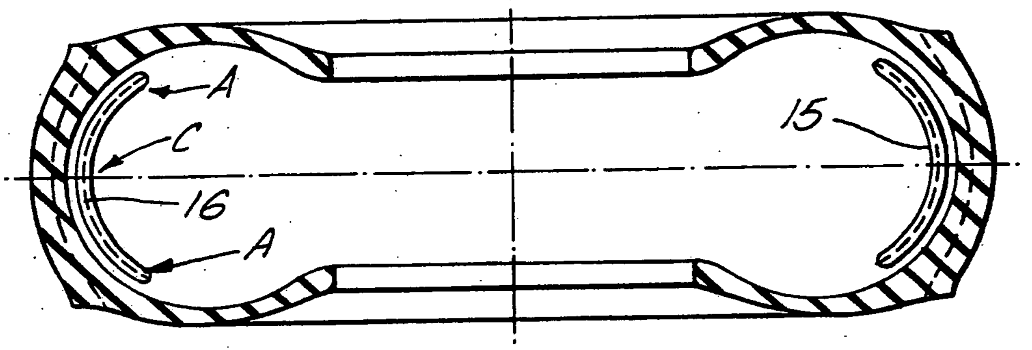


Fig.3.

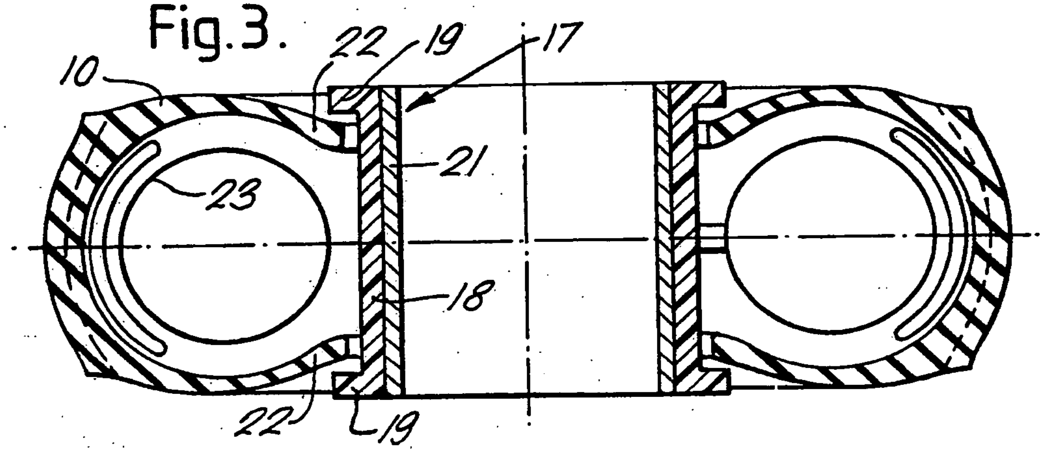
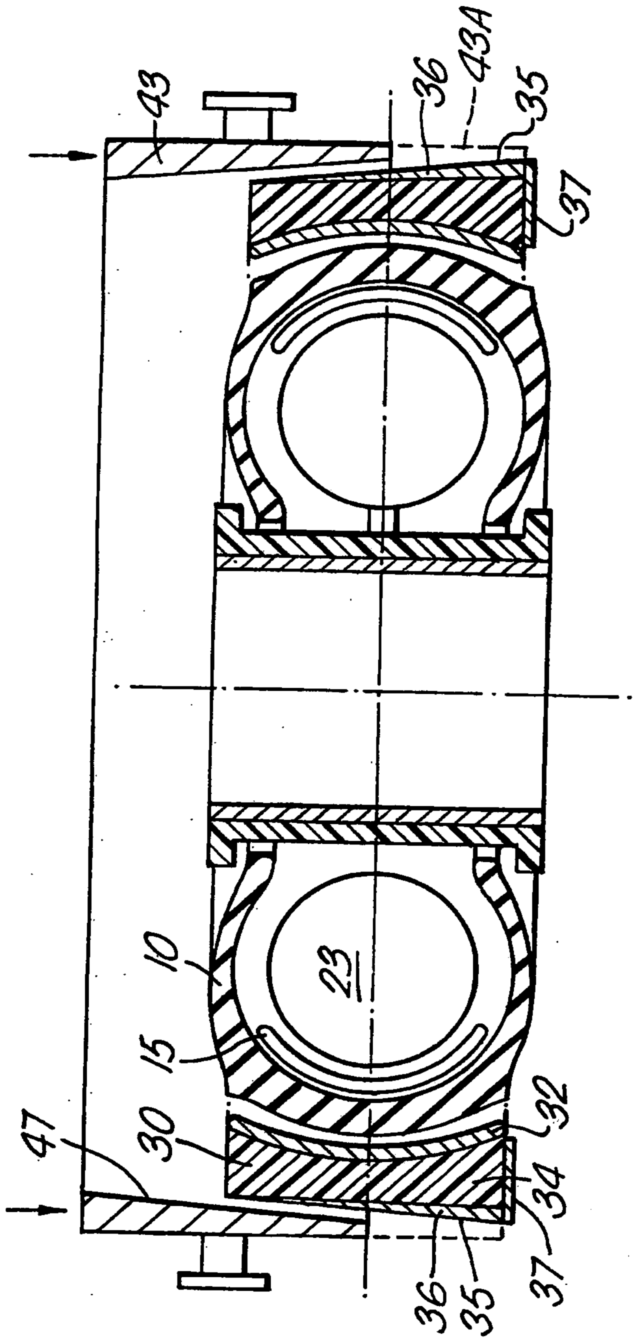


Fig. 4.



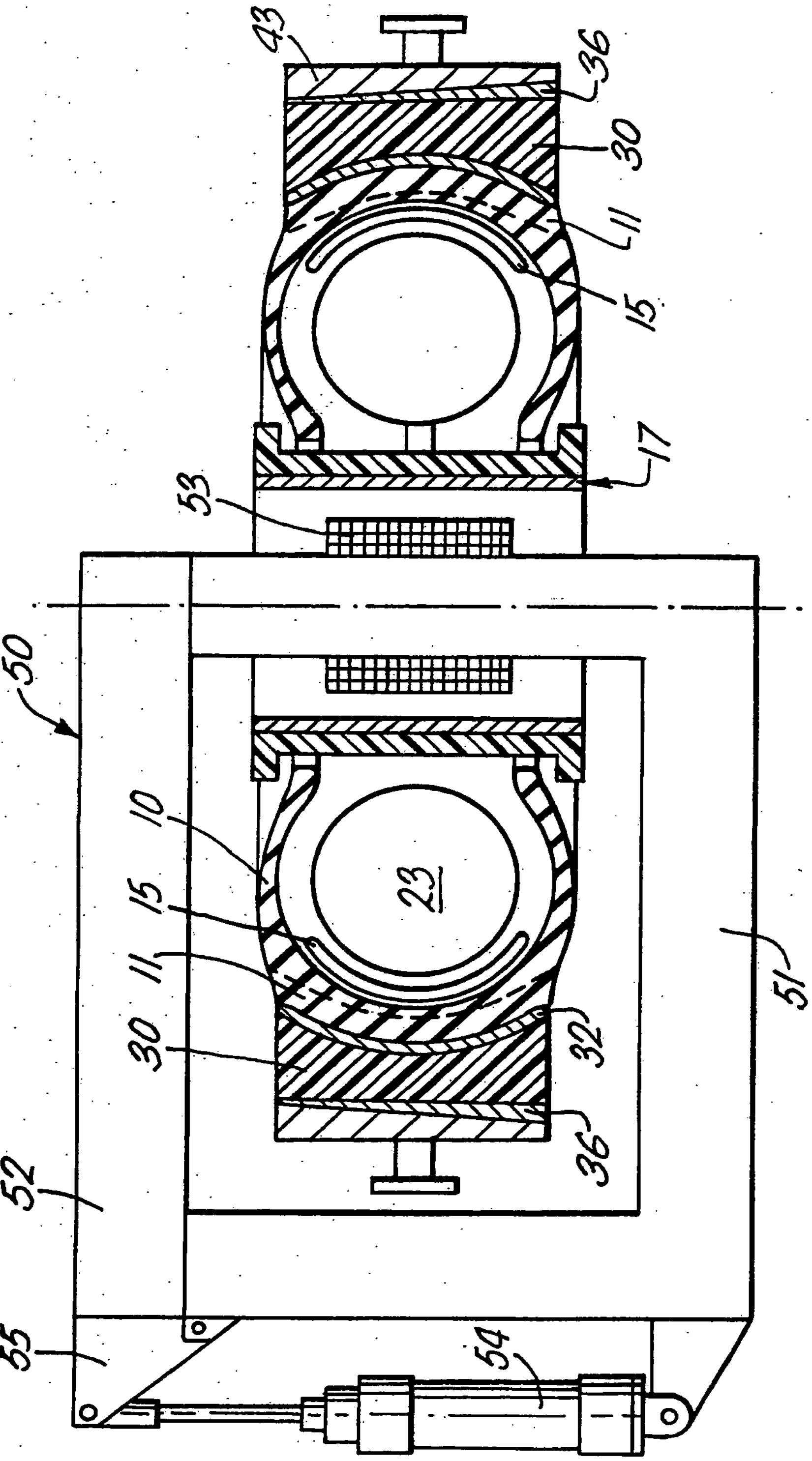


Fig.5.

Fig.6.

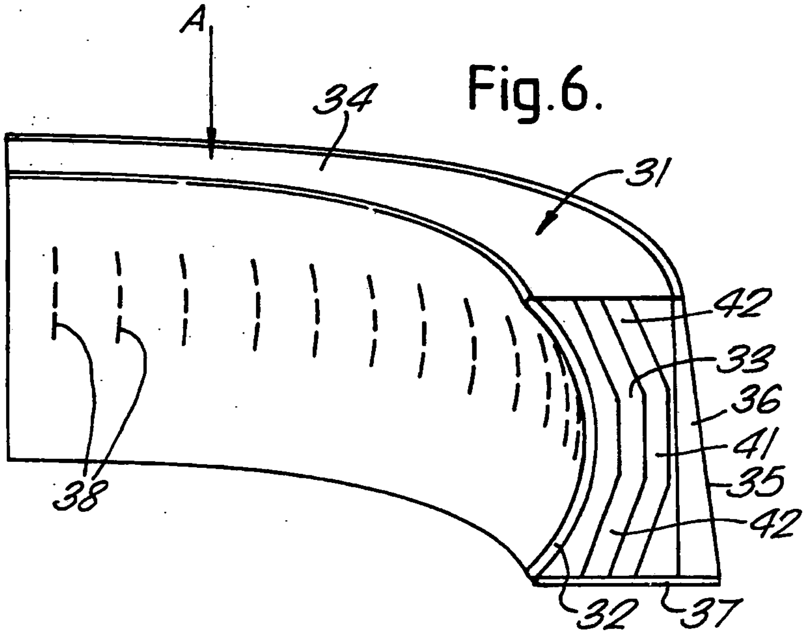


Fig.7.

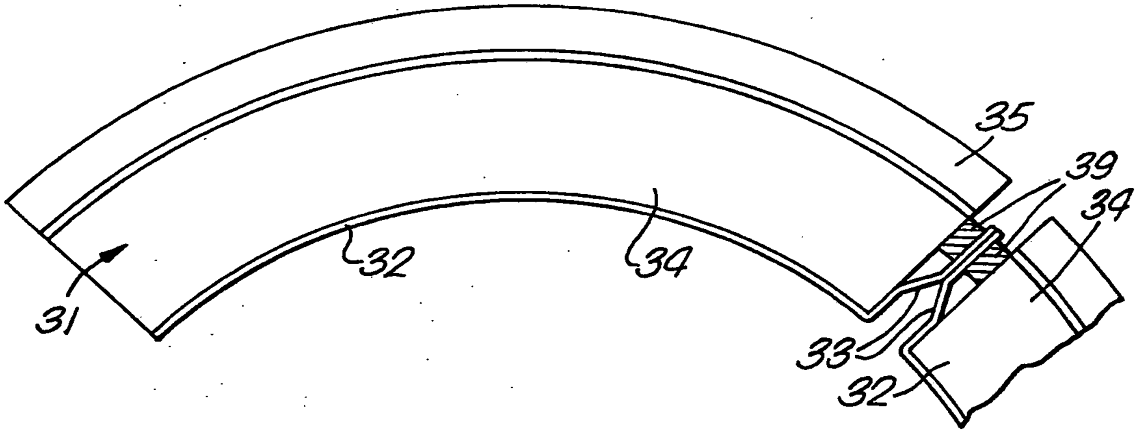


Fig.8.

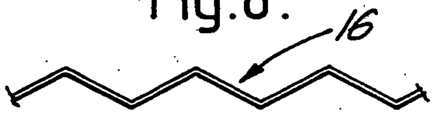


Fig.9.

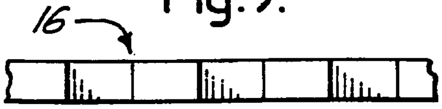


Fig.10.

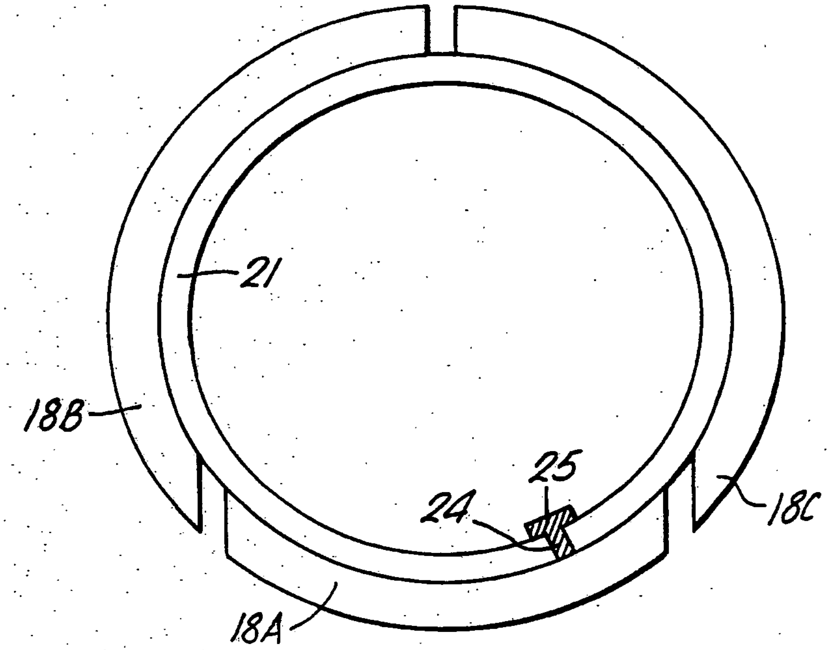
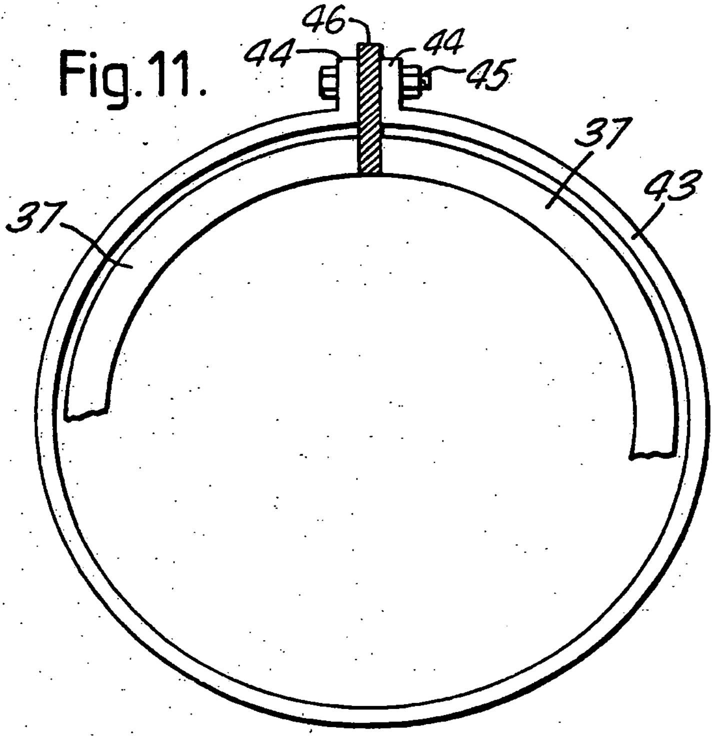


Fig.11.



# METHOD AND APPARATUS FOR TYRE RETREADING

This invention relates to a method of retreading pneumatic tyres.

The process of retreading a pneumatic tyre typically involves removing a tread from a used tyre carcass by means of cutting and grinding type machines. After the carcass has been prepared by removal of the tread, a cement may be applied to the surface of the carcass for adherence of a tread stock to the carcass. A length of tread stock is then applied around the crown area of the tyre and the carcass and tread stock placed into a curing apparatus for curing the tread stock to the carcass. The tread stock may be of the precured type or may alternatively be unvulcanised rubber stock.

In a typical retreading process the curing apparatus is a steam heated mold or autoclave and for a truck tyre size 11R225 a typical cure time would be about 90 minutes for a consumption of about 60 lbs of steam (approximately 20 kw-hours of energy).

The present invention seeks to provide a method and apparatus for retreading a tyre which consumes less time and less energy than the typical steam retreading process.

Accordingly there is provided a method of retreading a pneumatic tyre in which tread stock is placed around a tyre carcass which has been prepared to accept the tread stock, wherein said method comprises:-

(1) placing an annular induction heating element around the crown area of the internal surface of the carcass,

(2) placing an annular induction heating element around the crown area of the external surface of the tyre,

(3) exerting and maintaining a compressive load on the crown area of the tyre so as to squeeze the tread stock against the carcass,

(4) placing the tyre with elements in situ within an induced electrical field to effect heat for curing the tread stock to the carcass.

Preferably an inflation pressure is applied to the internal surface of the tyre, and an inward load may be simultaneously applied to the external crown area of the tyre. This load may be applied through the external induction heating elements.

Also according to this invention there is provided an apparatus for curing rubber in the tread area of a tyre and including an internal annular induction heating means for placing within the crown area of the internal surface of a tyre carcass, an external annular induction heating element for placing around the crown area of the external surface of tyre carcass with tread stock thereon, and means for inducing a periodic electromagnetic current in the elements to cause them to heat the crown area of the tyre and carcass.

Preferably the internal induction heating element is in the form of a flexible annular belt having copper elements wound around the belt, and the external induction heating element is in the form of a surface layer of copper formed on an annular supporting housing of electrically and thermally insulating material. The external heating element may be formed from a plurality of arcuate segments.

The invention will be described by way of example and with reference to the accompanying drawings in which:-

Figure 1 is a cross-section of a radial truck tyre carcass prepared for retreading with the tread stock in place,

Figure 2 is a schematic drawing showing the tyre of Figure 1 with an internal induction heating means placed therein,

Figure 3 is a schematic drawing showing the tyre and element placed on a central wheel rim,

Figure 4 is a schematic drawing showing the external induction heating means in place around the tread stock and the consolidation unit brought into position,

Figure 5 is a schematic drawing showing the tyre, with induction means in place, located in a suitable induction current inducing apparatus,

Figure 6 is a perspective view of an arcuate segment of the external induction heating means,

Figure 7 is a schematic plan part-view of the segments of

Figure 6,

Figure 8 and Figure 9 are views of copper wire as is utilised for the internal induction heating means,

Figure 10 is a plan view of the central wheel rim and support tube as used in Figure 3,

and Figure 11 is a plan view of the taper ring used to consolidate the external induction heating means of Figure 5.

With reference to the drawings, in Figure 1 there is illustrated a cross-section through a tyre carcass 10 which has been prepared for retreading by removal of the original tread and then the addition of a new tread stock 11. The tread stock is preferably of the precured type or may be uncured rubber stock, and may be delivered in the form of roll or cut-to-length pieces. A retread cement 13 may be placed on the crown area of the carcass prior to positioning the tread on the carcass.

The internal induction heating means 15 is shown in place within the crown area of the internal surface of the carcass 10 (see Figure 2). The internal heating means is in the form of a flexible annular belt, preferably heat resistant elastomeric material, reinforced by copper wires 16 which extend circumferentially around the belt. The wires are arranged so that in the shoulder area A of the belt 15 the density of turns of wire per linear measurement of cross-section is greater than in the crown area C of the tyre, that is approximately 8 ends per inch (3 ends per cm) at the shoulder and 4 ends per inch (1.6 ends per cm) at the crown area. This is because during the curing part of the process more heat is required at the shoulders. The wires 16 (see Figures 8 and 9) in the belt are formed from 1.5 mm flat copper wire which is crimped at approximately every 3 mm. The wires are crimped to increase their resistance to electrical flow so that the heat build up in the belt can be controlled.

Whilst the wires have been described with evenly distributed crimps it will be immediately apparent that the density of crimps can be altered along a length of wire, and also as between wires at the shoulder area and wires at the crown areas, so as to achieve the desired heating effect in the belt.

In the next step in the process (see Figure 3) a central wheel rim 17 and inner tube 23 are placed within the carcass. The rim is shown in detail in plan view in Figure 10 and comprises an outer segment wheel member 18 having radially outward flanges 19 at each axial end, and a central pressure resisting sleeve 21. The wheel member 18 is made from an electrical insulator such as nylon and is formed from three arcuate segments 18A, 18B, 18C, which can be slipped into position within the bead portion 22 of the tyre carcass 10. The segments 18A, 18B, 18C are locked in position by the sleeve 21 which has an axial split 24 therein in which is located an insulating piece 25 which prevents eddy currents from circulating the sleeve and causing a heat build-up therein.

The external induction heating means 30 is shown in Figure 3 in location around the crown area of the external surface of the tyre. The external induction heating means 30 comprises a plurality (preferably three or four) of arcuate segments 31 (see Figures 6 and 7) which can be assembled together to form the annular heating means around the tyre carcass 10. Each segment 31 has an inner surface layer 32 formed from an electrically conductive material such as copper, or copper alloy. The copper layer is approximately 1.2 mm thick, however other thicknesses may be utilised. The thicker the layer the better thermal conductivity is achieved to even out 'hot spots' or 'cool spots' and the thinner the layer the less inductive energy is required for heating.

Thus the thickness of metal is a balance between the two requirements. The copper layer 32 in each segment 31 is connected for electrical continuity via resilient contacts 33 to the copper layer in each adjacent segment 31. The copper layer 32 in each segment 31 is backed up by a block of insulating material 34 such as nylon, epoxy resin, polyester resin, etc. The radially outer surface of each segment has a taper surface 35 thereon which can be formed directly onto the nylon block 34, or alternatively can be formed on a mild steel sector plate 36 carried on the back of each block 34. Each block 34 is fitted with an arcuate brass bearing plate 37 to facilitate sliding radially.

The heat distribution in copper layer 32 of the assembled induction heating means can be varied by several methods. Since it is desirable for the shoulder areas to be hotter than the crown areas, radial slits 38 (that is radial with respect to the axis of the tyre) can be put into the copper layer to direct and control the flow of eddy currents. The frequency of the slits and their lengths may be a matter of trial to achieve the desired heat distribution effect.

Also it is possible to shape the contacts 33 to tune the path length of the eddy currents around the copper layer. For example, the contact may be shaped so that there is a longer path length for the current in the crown portion of the copper layer 32 than in the shoulder portions. The crown portion 41 of the contact may be made longer than the side portions 42 so that the contact 33 has a 'U' or 'V' shape when viewed on the end face of the segment 31. The longer the flow path the cooler the copper layer for a given current input, since the length of the resistance path is increased. Alternatively the centre portion of the contact could possibly be omitted thereby stopping eddy current in that area so the crown area of the copper layers 32 is heated by thermal conductivity from the respective shoulder areas. The contacts 33 may each be supported from their respective blocks 34 by resilient insulating pieces 39.

An external consolidation unit in the form of a mild steel taper ring 43 shown in Figure 4 in full lines in a half operational position and shown in chain dotted outline 43A when fully in position to clamp the external induction heating means 30 against the tyre carcass 10. The tapered ring 43 is shown in Figure 11 and is a split ring having radially outward flanges 44 for clamping the end of the ring together by for example bolts 45, the end flanges being separated by an insulator 46. The insulator 46 may be extended radially inwardly to ensure that the brass bearing plates 37 do not form a complete circular path for the induced eddy currents. The radially inner surface of the taper ring has a taper surface 47 thereon that matches the taper surface 35 on the back faces of the heating element segments 31 so that when the taper ring is pushed over the assembled segments 31 the segments are moved radially inwardly to hold the contacts 33 together to form an electrically continuous induction heating element 30 from the connected copper layers 32, and also exert a load on the crown area of the tyre. A taper of $2^{\circ}$ has been found to be advantageous and this exerts a load of about 100 lbs per square inch (7 $kgs/cm^2$) on the crown area of the tyre. If the taper ring is not pushed fully home then the load exerted on the crown area can be varied according to the position of the taper ring relative to the assembled segments 31.

Although a mild steel taper ring has been found satisfactory it is considered that it is preferable for the taper ring to be formed from stainless steel, epoxy resin, or polyester resin type materials. This is because these materials will not effect the magnetic field, whereas a mild steel ring, especially when not pushed fully home to be concentric with the induction heating element, will distort the magnetic field.

As the taper ring 43 is pushed into position the tube 24 is inflated to 100 psi (7 kg/cm$^2$) internal pressure. The operative assembly comprising wheel rim 17, tyre carcass 10 with tread stock 11, induction heating means 15 and 30, and taper ring 43 are then positioned in an induction heating current inducing means 50 as shown in Figure 5. The current inducing means 50 comprises a typical laminated transformer core 51 of a cross-section of about 6 inches square (15 cms square) the upper portion 52 of which is moveable to allow the operative assembly to be placed around a primary coil 53 on the core 50. The upper portion 52 is pivoted to one side of the core and is raised and lowered by the action of a pneumatic or hydraulic powered actuator 54 connected between the main body of the core 50 and a double hinge 55 connected to the upper portion 52.

The primary coil 53 comprises a 100 coil turns of copper strip, about 1 cm wide and 2 mm thick. Because of the low operating voltage and the low frequency of the alternating current source the primary coil remains cool throughout the whole retreading operation.

For retreading a 11R 22.5 tyre, a 60 amp current supply of approximately 50 - 60 Hz frequency is connected to the primary coil for a period of 50 minutes. In this period a temperature of 140$^{0}$ is achieved and maintained in the tyre carcass, for the use of approximately 7 kilowatt-hours of electricity. Because of the low level of operation of the core 50 and primary coil 53 there is no danger of a heat build up or burn out, and therefore apparatus is virtually maintenance free.

The induction heating means around the tyre act as secondary transformer coils and the large current induced therein causes the copper elements to heat up to effect the cure heating for the tyre retreading operation. After the curing operation the operative assembly is removed from the core 50 and dissassembled by the reversing of the assembly process previously described.

CLAIMS

1. A method of retreading a pneumatic tyre in which heat-curable tread stock is placed around a tyre carcass which has been prepared to accept the tread stock, wherein said method comprises:-

(1) placing an annular induction heating element within the crown area of the internal surface of the carcass,

(2) placing an annular induction heating element around the crown area of the external surface of the tyre,

(3) exerting and maintaining a compressive load on the crown area of the tyre between the internal and external elements to squeeze the tread stock against the carcass,

(4) inducing currents in the internal and external elements to generate heat therein for curing of the tread stock squeezed against the carcass.

2. A method as claimed in Claim 1 wherein a wheel rim means is located within the tyre beads of a carcass to be retreaded and an inflation pressure is exerted within the carcass.

3. A method as claimed in Claim 1 or Claim 2 wherein the induction heating element external of the tread stock is segmented and is moveable radially inwardly to exert a load on the tread stock.

4. A method as claimed in Claim 3 wherein the load

exerted on the tread stock is approximately 7 Kgm/$cm^2$, and there is an inflation pressure within the carcass also of approximately 7 kgm/$cm^2$.

5. A method as claimed in any one of Claims 1 to 4 wherein the induced currents field are derived from a 50 - 60 Hertz alternating current which is fed into a primary coil of a transformer core for an energy input of approximately seven kilowatt hours during the curing process.

6. Apparatus for curing rubber in the tread area of a tyre and the apparatus including an internal annular induction heating means adapted for placing within the crown area of the internal surface of a tyre carcass for generating heat, an external annular induction heating element adapted for placing around the crown area of the external surface of the carcass with tread stock thereon for generating heat, and means for inducing a periodic electromagnetic currents in the internal and external elements to cause heat to be generated therein for transfer to the tyre carcass and tread stock.

7. Apparatus as claimed in Claim 6 wherein the internal heating means is a flexible annular belt containing a plurality of turns of copper wire arranged so that the density of turns of wire per linear measurement of cross-section is greater in the shoulder area of the belt than in the tread area of the belt.

8. Apparatus as claimed in Claim 6 and Claim 7, wherein

the external induction heating means is formed from a plurality of arcuate segments which are connectable for electrical continuity, and are separable for placement around or removal from the crown area of the tyre.

9. Apparatus as claimed in Claim 8 wherein the external induction heating means comprises a plurality of arcuate segments each of which has an inner surface formed from a layer of electrically conductive material, and a surrounding outer housing of an electrically and thermally insulating material.

10. Apparatus as claimed in Claim 9 wherein the arcuate segments each have a tapered external surface on the radially outer face of their housings and wherein the apparatus further comprises a consolidation unit having a tapered internal surface matching those of the arcuate segments, said unit when pushed over the segments pulls the arcuate segments together to exert an inward load on the tread stock.

11. Apparatus as claimed in any one of Claims 6 to 10 wherein the tyre carcass is mounted on a central wheel rim made of an electrically insulating material, so that an inflation tube can be enclosed within the carcass and is inflatable to exert a load on the internal induction heating means.

12. Apparatus as claimed in Calim 11, wherein the wheel rim comprises a plurality of arcuate segments which are

held in position by an internal pressure resisting sleeve.

13. Apparatus as claimed in Claim 12 wherein the pressure resisting sleeve is a steel sleeve having an axial slit therein, in which there is located an insulating piece to prevent eddy currents from circulating in the sleeve.

14. Apparatus as claimed in Claim 10 wherein the consolidation unit is in the form of a split ring having an insulating piece located between the ends of the split ring.

15. Apparatus as claimed in Claim 9, wherein the electrically conductive material has radial slits in its crown area to control the flow of current in that portion of the induction heating means.

16. Apparatus as claimed in Claim 8 or Claim 9 wherein the segments of the external induction heating means are connected via resiliently loaded contacts which can be formed so as to vary the current pathlengths around the heating means to achieve a desired heat distribution.

17. Apparatus as claimed in Claim 6, wherein the means for inducing the periodic current includes a laminated core having one portion which is removeable from the core to place the tyre with induction curing means thereon concentric with a primary coil on the core, said one

portion being pivoted to the rest of the core and being moveable by fluid actuator means.

18. Apparatus for curing rubber in the tread area of a tyre by use of electromagnetically induced current substantially as described herein and as illustrated in the accompanying drawings.

19. A method of retreading a pneumatic tyre and which is substantially as described herein with reference to the accompanying drawings.

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